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ABSTRACT

The GK-12 program of the National Science Foundation is an innovative program for enriching the value of graduate and advanced undergraduate students' education while simultaneously enriching science and mathematics teaching at the K-12 level. GK-12 is a fellowship program that offers graduate students and advanced undergraduates the opportunity to serve as resources for K-12 teachers of science and mathematics. An evaluation was conducted to provide information about GK-12. One component of the evaluation was the qualitative analysis of case studies from 12 purposively selected sites, and the other was a quantitative analysis of survey data from all project sites. Findings show that the areas most often cited as strongest program areas were: (1) content knowledge gains for teachers; (2) positive role models for students; (3) improved school-university relationship; and (4) improved communication and instructional skills of Fellows. The two areas most often cited as "less strong" were: (1) clarification of the Fellows' and teachers' roles; and (2) summer training. The most often cited implication for the GK-12 Program as a whole was sustainability. Overall, the program appears to be meeting its goals. To provide better information, surveys are being conducted of all Fellows, about 1,000 cooperating teachers, about 1,000 graduate students not receiving GK-12 support, and school district staff in participating school districts. (SLD)

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Evaluation of the National Science Foundation Graduate Teaching Fellows in K-12 Education (GK-12) Program

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Evaluation of the National Science Foundation Graduate Teaching Fellows in K-12 Education (GK-12) Program

Background. NSF's GK-12 Program is an innovative program for enriching the value of graduate and advanced undergraduate students' education while simultaneously enriching science and mathematics teaching at the K-12 level. GK-12 is a fellowship program that offers graduate students and advanced undergraduates the opportunity to serve as resources for K-12 teachers of science and mathematics.

The GK-12 program made its first awards in the summer of 1999. The "First Cohort" of grantees consists of 31 projects in 24 states and Puerto Rico. (*Project* refers to the GK-12 activities implemented by a university and includes all of the Fellows who are awarded GK-12 grants at that institution.) Urban, suburban, and rural locations are included in this mix. Because of the funding cycle, 11 of the projects placed GK-12 Fellows in the field for some portion of the first year, while the remaining projects waited until the fall of 2000 to do the same. There were 109 Fellows in the schools for part or all of the 1999-2000 school year: 73 graduate students and 36 advanced undergraduates. When all projects from this First Cohort were fully deployed for the 2000-01 school year, approximately 300 graduate students and 100 undergraduates were in the field.

In response to the 2000 GK-12 Program Solicitation, another round of proposals yielded additional projects for a "Second Cohort," so these counts of graduate and undergraduate students in the field are growing apace. At the time of the evaluation, 56 projects had been funded in Cohorts 1 and 2. GK-12 awards are in the range of $200,000 to $500,000 per institution, per year, for three years. The individual Graduate Teaching Fellows receive $20,500 per year as well as up to $10,500 toward the cost of their education. Fellows may be funded for one or more years; such decisions are made by the individual projects.

The GK-12 projects are in diverse geographic locations and have foci in science, technology, engineering, and mathematics (STEM). Six projects out of 31 in Cohort 1 have engineering as the focus of their effort. Others range from a focus on the Mississippi River ecosystem to developing special modules for hearing-impaired students in North Carolina, and from evolutionary biology on the Big Island of Hawaii to automotive technology at Penn State. Seventeen of the projects cover all grades from kindergarten to twelfth, but many specialize at a particular level with four having an elementary focus, six having a middle school emphasis, and four concentrating on high school. Some GK-12 project designs use a "Classroom Immersion" plan where the Fellow works directly with one or two Cooperating Teachers[1] and their students; other projects use an "Exposition Model" in which Fellows do presentations in many classrooms across a number of schools or districts.

The GK-12 Cohort 2 sites are equally diverse in their locations and scope of work. Within the 25 sites, 24 span the continental United States, and one is located in the commonwealth of Puerto Rico. The site topics vary among the areas of science (including chemistry, biology, physics, and ecology), technology, engineering, and mathematics. Some sites have chosen to work with the entire K-12 population; others focus on elementary, middle, or high school grade levels across schools and/or districts. A number of the projects employ

[1] The K-12 teachers who participate in the GK-12 Program are called Cooperating Teachers.

hands-on approaches and inquiry-based learning for students as the focal point of their work, while others integrate research, teaching, and curriculum development into their projects.

A third cohort of 22 colleges and universities received three-year GK-12 Program grants in 2002. With these grants, graduate students were to receive annual stipends of $21,500 plus a cost of education allowance; undergraduate students, up to $5,000 per academic year (plus an additional $5,000 for teaching and other activities during the summer.)

Most of the Fellows receive courses in communication skill-building and teaching strategies before entering the K-12 realm. These seminars or workshops last from one week to ten weeks during the summer, with two weeks being average. Typically, Fellows are required to spend ten hours per week in a K-12 setting and five hours per week in preparation.

Despite the fact that the funding and Fellows are university based, the majority of participant activities with K-12 teachers and students are expected to occur in the schools. GK-12 Fellows, selected by grantee institutions, work directly with the teachers to demonstrate key concepts; connect elementary and secondary learning to the habits and skills required for future study in STEM disciplines; provide role models for future STEM professionals; enhance teachers' content knowledge and understanding of the principles of science and mathematics; and assist in science and mathematics instruction.

Purposes of the evaluation. The purposes of the evaluation are to produce information about the GK-12 Fellows program that NSF can use to inform decision makers about how sites are implementing the program, improve the quality of the program, and to assess the extent to which the overall GK-12 Program is achieving its specified program outcomes:

1. Improved communication and instructional skills for the Fellows
2. Professional development opportunities and content gain for K-12 teachers
3. Enriched learning by K-12 students
4. Strengthened partnerships between institutions of higher education and local school districts

There are consequences, both anticipated and unanticipated, of programs that involve graduate students and the local K-12 system. Accordingly, it was decided to try to assess the impacts of the projects on graduate education at their college or university.

Evaluation design. In order to meet these purposes, the evaluation has two major components. One is a qualitative analysis of case studies of purposively selected sites. Qualitative analysis is the most appropriate methodology for determining the variability among the sites, for learning how future in-depth studies can be conducted to assure that the goals of the program are being met, and for fulfilling NSF's purposes within the available resources. We have chosen a case study approach in an effort to understand the unique complexities at each site related to the different organizational structure of universities, different student populations served, different relationships between universities and school districts, and different project designs implemented by the GK-12 program grantees. Case study methodology, which is particularly suitable for producing enriched descriptions of a site's implementation of the program, can inform about how the program is being implemented at selected sites, how the four goals of the program are being met at these sites, and what action, if any, needs to be taken to improve the program.

The second major component is a quantitative analysis of survey data collected from all of the project sites. These surveys are being administered now, to Principal Investigators, cooperating teachers, school district staff, GK-12 Fellows, and a sample of graduate students receiving other forms of support. These surveys are being conducted in order to learn what the case studies have in common and to determine how generalizable findings are to all of the projects. The surveys will also provide descriptive information about the total population of those participating in the program, support analyses of associations between project characteristics and outcomes (to inform about how the program might be improved), and help estimate the degree to which the program is attaining its goals.

Data collection activities in 2001-2002 included visits to six projects to observe the training provided to participating Fellows and cooperating teachers and 3-day site visits to twelve case study sites.

These 12 sites were selected to maximize variation with respect to the following dimensions:

- Region: Four projects were selected from each of three regions (eastern, central, and western states)

- Grade levels of students served: Projects were selected that served each of four different grade levels (Elementary, Middle, High School or K-12)

- School characteristics: Projects were selected that served schools in each of three different types of communities (Urban, Rural, Suburban)

- Year of Implementation: Projects that began in each of three different years (1999, 2000, 2001) were selected.

The twelve case projects for which case study site visits were conducted are the focus of this paper. We are currently conducting another twelve site visits. However, since these visits are in progress, results are not yet available for reporting purposes.

Case study site visit preparation. A total of eleven different data collection instruments and focus group guides were prepared and approved by the Office of Management and Budget for the conduct of this research. Approval for this research was obtained from both AIR's and the University of Wisconsin's IRB.

In order to prepare staff for the site visit, a Site Visitors Training Manual was developed and distributed. Training sessions were conducted, via teleconference for AIR and WCER staff; on-site training by senior staff with scientists and master teachers preceded their interactions with teachers and Fellows.

Site visit activities. Interviews, focus groups, and classroom observations were conducted during each site visit. At each project, interviews were conducted with:

- The Principal Investigator (PI) and Co-Principal Investigators (co-PIs) of the project

- The Dean of the project's Graduate School

- Three randomly selected[2] GK-12 Fellows

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[2] Stratified random sampling was employed to insure the selection of graduate and undergraduate Fellows (if both were present at a project). If the project only had graduate Fellows, gender served as the stratification variable.

- These Fellows' academic advisors

- The K-12 teacher who worked most closely with each of these Fellows

- The principals of the schools at which these teachers worked

- Three graduate students in similar graduate programs who were not receiving GK-12 Fellowships

- The project evaluator

- The professional development provider

At each project, focus groups lasting between 60 - 90 minutes were conducted with:

- 5 - 10 K-12 teachers involved in GK-12 project and not interviewed

- 5 - 10 GK-12 Fellows (other than those individually interviewed)

An observation protocol was employed for the evaluation of the selected Fellows during their interactions with students. These observations generally lasted between 30 and 50 minutes. In addition to AIR/WCER staff (consisting of an experienced site visitor and a junior staff member), a nationally certified master teacher and a scientist also participated in the observation sessions and in teacher interviews. The board-certified master teachers were able to assess the Fellow's teaching skills; the scientist was able to assess the technical accuracy of the science presented. The master teacher and scientist were present for only one day (of the three day site visit).

Analysis. After the site visits, the two researchers wrote a report following a fixed outline:

I. Overview of Project Visited

II. University Role in the Project

III. School and District Role in Project

IV. Fellows' Roles in Project

V. K-12 Teachers' Roles in Project

VI. Evaluation of the GK-12 Project

VII. Summary

These reports summarized data collected through administration of the interview forms, focus group guides, and observation forms. It also incorporated information provided by the scientist and expert teacher, who prepared one- to two-page reports specifically addressing the quality and appropriateness of the content (science, technology, engineering, and mathematics) and the quality of the instructional experience, respectively.

The two researchers aggregated information from the different informants by organizing their responses by specific research questions embedded in the report outline. Tentative conclusions were drawn when there were confirming responses from different people to the same research question. When conflicting information was received, researchers: (1) sought information corresponding to other research questions that may resolve the conflict; (2)

telephoned or e-mailed the respondents to clarify the issue; and/or (3) judged that there were legitimate reasons for conflicting views and documented these reasons in the report.

The common report structure facilitated the importation of data into NU*DIST software, facilitating cross-site analyses. Results of these analyses follow.

Cross-Site Case Study Analyses:

I. Fellows' Improved Communication and Instructional Skills as an Impact of Their Participation in the GK-12 Fellowship Program

Fellows, their advisors, the teachers they worked with, and project leaders strongly believe that the GK-12 Fellowship Program has improved Fellows' communication and instructional skills. The consistency of this finding across the sites visited provides a reasonable likelihood that the finding is true across the full range of sites in the program. The only instances noted that suggested the Fellows' communication or instructional skills were not enhanced were in cases where the Fellows joined the program with a developed spectrum of effective skills. At three of the 12 sites visited, a Fellow or project director indicated the Fellows joined the program with good communication skills. At one of these sites, one Fellow claimed to already have good instructional skills. At least 75 percent of the 36 Fellows who were randomly selected to be interviewed said that their communication skills had been improved because of their participation in the GK-12 Fellowship Program. At least 85 percent of these Fellows reported that they had improved their instructional skills. Faculty advisors, project leaders, and cooperating teachers verified these findings.

Fellows' improvement in instructional skills was related to their improvement in communication skills. Fellows became more effective teachers as they learned how to communicate better with K-12 students. The reasons Fellows gave for improved instructional skills included their increasing ability to distill information to present to students and their capacity to gauge the learning level of students.

Fellows or teachers at ten of the 12 sites visited explicitly reported that the Fellows' communication skills had improved because of their participation in the GK-12 Fellowship Program. Only one Fellow at one site said her communication skills had not improved because her skills were already effective—in part because she had just completed a master's degree in education. The other two Fellows at this site reported improved communication skills. At two other sites, the project director and advisors indicated that the Fellows came to the program with excellent communication skills. The teachers at one of these sites were pleasantly surprised that the Fellows came with very satisfactory communication skills.

Fellows improved their communication skills in a number of ways. The two most frequently reported ways by both Fellows and project leaders were that Fellows became better at gauging their audience and at articulating difficult concepts clearly. They did this by considering the cognitive levels of the students they were addressing, using more appropriate vocabulary, considering prior knowledge, and selecting more age-appropriate and experience-appropriate examples. At least four Fellows of the 36 randomly selected for this survey indicated that they had gained greater confidence in speaking to large audiences and were more willing to voice their opinions. One Fellow expressed greater confidence in speaking to his advisor. Two Fellows became more open-minded regarding what students knew. One Fellow had learned different

formats for presenting content, including developing computer-based resources. Another Fellow became a more effective communicator by becoming a better listener. Fellows found that unlike undergraduate students, students in elementary and middle schools let the teacher know when they did not understand something.

One master teacher explicitly commented on the communication skills practiced by a Fellow during a lesson she observed, *"This Fellow spoke clearly, related the content to the students' lives by referencing things that were familiar to them, constantly referred to previously learned lessons, stood close to the students when re-teaching misunderstood content, and developed a good rapport with the students."* Other master teachers and scientists made similar comments about how the Fellows worked with students. Even though these observations do not verify the impact of the GK-12 program on Fellows, they do support the contention that Fellows were observed using good communication skills. These observations, along with the reports by Fellows and others, increases the confidence that the GK-12 Fellowship Program is having an effect.

Fellows, supported by the comments of others, described in some detail that they had improved their instructional skills from participating in the GK-12 Program. A few Fellows revealed that they had never taught before, or had only tutored individuals. Because of the experiences they received through the GK-12 Program, these Fellows are more confident in working with large groups. These and other Fellows indicated that they are better able to present scientific ideas in a form that is understandable and at a pace that is more appropriate for younger children. Some Fellows learned pedagogical skills such as paying attention to learning styles, trying different presentation techniques, writing lesson plans, teaching a scientific concept in more than one way, and different ways of demonstrating ideas. One Fellow explained:

> *"We have begun to think in terms of learning styles; it's not just about lecturing, but finding age-appropriate content and presenting and connecting with students."*

Another Fellow described one of his experiences:

> *"I was doing a demonstration on Archimedes' Principle, and a student asked me about the hole [air bubble] in the submarine that divers go into. I didn't know the answer. [The teacher] put a glass upside down in a sink to show how it works. I knew the theory, but didn't know how to show that, and he had good demonstrations to show how [things] happen."*

It is not only the students who gained from Fellows improving their instructional skills, but Fellows also reported receiving a benefit. Fellows from at least two sites valued revisiting basic science content that are easily ignored in an intensive, highly-specialized graduate program. One Fellow commented, *"It's been great to review the basic things I learned in science long ago."*

Our visits to six sites to observe the professional development experiences the different projects offered to Fellows provided some insights into how the GK-12 Fellowship Program improved Fellows' communication and instructional skills. All six programs provided Fellows with some structured professional development experiences. Some programs featured a semester seminar that met weekly. At one site, Fellows had a two-week seminar in the spring and then attended additional two or three week institutes in the summer. Some of the sites held weekly meetings of the Fellows during the academic year. In the organized sessions, Fellows were

offered a variety of experiences, including instructional and planning techniques. At some of the sites, Fellows were given explicit instruction on communication skills, questioning techniques, and ways to frame the content to more effectively relate to students' thinking and experiences. Some of the projects that were visited required Fellows to keep journals or logs of their experiences. For example, one Fellow observed that because she kept a journal required by the local GK-12 project, she was writing more. She found writing to be a *"great tool for communication,"* one that would be useful for her dissertation. The structured professional development experiences provided by the GK-12 Program offer at least one explanation for the Fellows' improved communication and instructional skills. This explicit training, along with explaining concepts to students, developing instructional materials, discussing with colleagues their interactions with students, and receiving feedback from the cooperating teachers all represent factors built into the GK-12 Fellowship Program that could lead to improved communication skills by Fellows.

Fellows' comments offer insights into how the GK-12 Fellowship Program contributed to their improved communication and instructional skills as compared to other possible factors, such as maturation, increased experience in their field, serving as a teaching assistant, or normal interactions with other graduate or undergraduate students. One Fellow mentioned that returning to the basic scientific principles required to instruct K-12 students helped him to better articulate difficult concepts more clearly. Other Fellows interviewed made the same observation. Another Fellow, at a second site, attributed her improved explanations of scientific concepts to students to the fact she learned more about these students, their motivation, their academic history, and their career aspirations. A Fellow at a third site claimed that through her collaboration with an elementary teacher she gained experience in conveying ideas to second and third graders by taking into account these students' cognitive skills, which she needed to be aware of when she had to rephrase a question to better correspond to a student's abilities.

Common to all of these Fellows' comments is that, as a result of working more closely with K-12 students and their teachers, they have become more effective in phrasing scientific ideas to make them better understood by the younger students. At least 10 percent of the Fellows interviewed indicated that their experiences with the classroom teachers were more important for their improved communication and instructional skills than the professional development experiences. It was not only teaching—an experience a graduate student can gain as a teaching assistant—but it was in working with younger students in a context requiring greater understanding of their students' thinking that has contributed to Fellows' improved communication skills. As one Fellow specifically noted, undergraduate students do not give you feedback when they do not understand something, whereas the younger students do. A Fellow at another site reported a sharp contrast between the GK-12 program and being a teaching assistant more directly:

> *"Most of the TA stuff is talking at a group of people, lots of blackboard work, talk and talk and talk and [the students] scribble [notes]. At the K-12 schools, I worked with lots of small groups [of students] and had to keep them on task and keep them engaged.... For this work I actually had to keep it interesting."*

II. Enriched Learning by K-12 Students

Enriched student learning can be facilitated by GK-12 projects in many ways. For example, Fellows can design or provide effective materials and resources; through interactions with Fellows, teachers can acquire content knowledge and pedagogical knowledge and use their newly acquired skills to provide enriched learning experiences; and GK-12 Fellows can provide enriched learning experiences directly to students. There was strong evidence of enriched student learning at each of the twelve sites that were visited that could be attributed to one or more of the above mechanisms. This evidence was provided by our direct observations of classroom instruction (and verified by the simultaneous observations of master teachers and scientists) as well as through the focus groups and interviews that were conducted with Fellows, teachers, principals, and project evaluators.

The reports of these master teachers frequently provided compelling evidence of enriched learning. In the following examples from two different projects, Fellows' advanced understanding of science and mathematics allowed them to challenge students' thinking and to have students think more deeply.

> *"When the students were completing their assignments, the Fellow monitored, clarified misunderstandings, and re-taught important concepts and points of the lesson. This was an effective use of the Fellow's expertise and time. Because of his knowledge of mathematics, he could easily diagnose the students' misunderstandings and misconceptions, as well as extend the learning of students who needed to be challenged."*

> *"The Fellow showed exceptional care in asking students to move beyond simply answering their questions, but to reason, and communicate their reasoning. The students responded by showing deep understanding about probability that is often not seen in seventh graders.[3]"*

At all of the projects visited, teachers were able to provide examples of positive impacts of the Fellows that increased students' opportunities to learn science and mathematics. At one site, Fellows were able to change teachers' expectations about their students' abilities. At this site, during a focus group, a teacher reported:

> *"Sometimes I underestimate what the students can handle, so he [the Fellow] has counterbalanced that a bit. He has been good for me to check myself about whether or not I am challenging the students enough."*

At another project, a teacher said, *"The Fellow also did things I would not have attempted (dissecting a bullfrog in seventh and eighth grade) on my own."* Other teachers at these sites supported these statements. Raising teachers' expectations will clearly enrich the learning opportunities provided to students.

At a different project, the Fellows' training in mathematics education helped them recognize the importance of providing students with an understanding of the mathematics underlying the arithmetic exercises and activities that go on in the classroom. Accordingly,

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[3] It should be noted that the second Fellow had just received a master's in education and had worked with these students, as a student teacher, the preceding semester. However, even if some Fellows did not acquire their skills through participation in GK-12 project training, the Fellows are still facilitating or providing enriched learning opportunities and experiences for K-12 students.

Fellows were able to help students learn mathematics and help teachers learn more about how to teach mathematics. One teacher told us that the Fellow showed her that you cannot teach mathematics as a mechanical process. Instead, you have to teach the students to understand what they are doing.

Numerous examples of enriched learning experiences were provided by teachers, principals, Fellows, and our direct observation. Examples from six different projects follow:

- Due to Fellow's computer skills and leadership skills, the students have learned to use computer-based applications and technology.

- A teacher was impressed with the way her Fellow bridged the gap between the university and the high school by encouraging students to correspond with professors who were working in similar fields. The Fellow helped students send email to professors with specific questions and followed up with the professors to ensure the students received prompt replies.

- At one site, the teachers felt that the Fellows' expertise and their access to resources and supplies offered many opportunities for enriched student learning. One teacher commented, *"In high school biology the things we were able to do that otherwise would not have been possible was gene technology stuff using equipment that is really expensive. .. [The student] got to use these pieces of equipment and when they see DNA testing on TV and learn about it, they now know the process that's involved and the equipment that's needed."*

- One teacher told about a laboratory exercise where students explored the effect of the angle of a ramp on a car's speed. The Fellow took their data, plotted the group's data, pooled it, and ran a regression. It worked well. Some measurements were off and that led to a discussion of how to collect data. On another lab that followed, the teacher reported that the students had improved their data collection skills.

- At another site, a teacher described things the Fellow could do with the students that she could not, like taking them to the university to look things up for science projects or taking them on a field trip to the university to visit three or four research labs. Another teacher commented, *"Much more than I, he can get students to see that what they are doing is real science."*

- In our classroom observations, we saw strong evidence of enriched learning. There was a fourth grade "science day exhibition." This consisted of science demonstrations and presentations that stimulated and informed the children. The fourth graders formulated and tested hypotheses and thought creatively. At one station, they investigated different types of soils, tried to predict their water retention properties, and then experimentally tested their predictions. The students were using and applying sophisticated scientific terminology correctly. They were genuinely engaged and excited by this activity, which was largely planned by the Fellows and supported through funds provided by the project.

At another project, there was quantitative evidence of enriched student learning. Specifically, at one participating school, in the 2000-01 school year, only 20 K-12 students in the district participated in the Science Fair and Science Olympiad. In 2001-02, the district science

coordinator reported that, with the assistance of the Fellows, 70 K-12 students entered the competition. At the same project, the principal at one school said that the Fellows' assistance had a direct impact on students' mathematics scores. A pre- and post-test was given in mathematics classes where Fellows were assisting. Their mathematics scores increased substantially.

Simply the presence of another adult in a classroom can facilitate enriched learning by allowing teachers to provide more individualized attention to their students. This point was raised by several teachers -- particularly those who were not really taking advantage of the skills, training, and knowledge that Fellows brought with them into the classroom. However, the ease with which examples of enriched student learning were elicited from educators strongly suggests that these examples are not atypical or rare events.

III. Strengthened Partnerships Between Institutions of Higher Education and Local School Districts

Cross-organizational collaborations are usually intended to strengthen ties between organizations. However, organizations do not collaborate. Individuals within these organizations work together towards common goals and objectives. The process of working together (particularly when goals are attained) is often adequate to bring about mutual understanding and create trust. This, in turn, will create new relationships, strengthen existing relationships and thereby serve as the basis of future partnerships.

All of the principals interviewed, almost all of the teachers interviewed, and nearly all of the teachers who attended the focus groups positively evaluated the GK-12 projects with which they were associated. Such relationships, whose development was facilitated by their positive experiences with the GK-12 projects, are particularly important for designing and implementing new projects.

If a goal of the GK-12 Program is to *create* partnerships between institutions of higher education and local school districts, we would have to label the program a failure. At only two projects were relationships with new school districts created. In one of these, the district played an important role in planning the project, and a successful partnership seems to be developing. The PI of this project told us:

> *"We really interact with these teachers on a collegial basis, and they don't usually get that kind of treatment ... from the university. We all have higher opinions of the schools than we did before. We see the limitations of supplies and equipment more than teacher training. Essentially all of our teachers are excellent."*

The project's evaluator confirmed this, adding that the project has opened up a discussion at the university about the importance of outreach into the local community.

At the other project in which a new partnership was created, the development of the relationship was at the explicit request of NSF, which told the PI to recruit a high minority school for their GK-12 project. One of their project's research partners, a private university lab school, connected them with this school.

However, the goal of the GK-12 Program is to *strengthen* relationships with local school districts rather than to create them. It appeared that, at all of the sites visited in the past year, recruitment of teachers and schools was built, predominantly or exclusively, on pre-existing relationships that the university or project leadership and project staff had developed with individual teachers and site administrators. These relationships were largely developed through participation in university/K-12 outreach projects and university-affiliated teacher professional development programs. For example, one GK-12 project was located at a university with an exceedingly extensive outreach program into the local schools. The project was able to collaborate with 13 pre-existing university based programs that worked with K-12 schools. At another project, all three of the university's senior personnel on the GK-12 project were active participants in a coalition developed to assist in the development of the district's Urban Systematic Initiative (USI). In fact, there have been over 45 projects between the project's university partners and the local school district.

A third project was at a university that has a long history of collaboration with their local K-12 school district. Their university's Physics/Astronomy Department has been collaborating with the district for 25 years on a project entitled "Saturday Science" that involves 100 fifth and sixth graders yearly in a four-week session of hands-on science activities. At this university, Eisenhower funds were used to conduct a pilot project that served as a basis of the GK-12 project. The GK-12 project was an elaboration of this project, allowing its continuation with schools that and teachers that participate in the pilot. Similarly, at a fourth university, NSF and university funds were used to develop another pilot project that become, with slight modifications, one of the university's GK-12 projects.

In a program like GK-12, most of the relationships that developed were between the teachers and the Fellows with whom they worked. But, Fellows could also facilitate relationships between teachers (and students) and university faculty. At one project, a teacher was impressed with the way her Fellow bridged the gap between the university and the high school by encouraging students to correspond with professors who were working in similar fields. The Fellow helped students send email to professors with specific questions and followed up with the professors to ensure the students received prompt replies. At another project, school staff commented on increased communication between K-12 school staff and the university. This was felt to be one of the most positive aspects of the project. The university-level respondents confirmed this, identifying cooperation with the two school districts, and increased K-12 use of university facilities and resources as some of the most successful accomplishments of the project. By taking the students to the university on field trips, the Fellows provided the students with the chance to consider going to college ... as well as to see female and minority scientists. One teacher referred to the project's PI as "Santa Claus" because he hand-delivered books and materials to the schools that were purchased with GK-12 funds.

At another project, the project leaders commented on the impact of the GK-12 project in further expanding university-to-school-district interactions, through shared knowledge, expertise, and resources. Teachers commented favorably on expanded contacts and interactions with the university. They wished to establish even closer ties.

Similarly, at another project, a project leader said that Fellows facilitated communication between university faculty and middle school staff. Teachers reported this as one of the project's major benefits. And, at yet another project, the Fellows felt that, outside of their influence on students, the project was most successful at fostering partnerships between the schools and the

universities. At this project, several of the teachers, in their focus group, commented favorably about their increased access to the universities and their science resources. And their principal felt the school would benefit from more contact with the university, and wanted to see the GK-12 project expanded.

The fact that most of the relationship development and strengthening impact was at the school level is particularly important. School district involvement in the development and implementation of the projects that were visited was minimal. At only two of the twelve sites visited was there significant involvement of school district staff in the project planning process. At one of these projects, during the planning phase, sustainability and buy-in were identified as critical factors. Accordingly, the superintendents of the partnering districts agreed to contribute a portion of the stipend ($9,000) of each graduate Fellow working with their institutions. These matching funds allowed the project to support undergraduate Fellows, who would work in the district with the graduate Fellow.

However, this was the exception. At the other ten projects, districts had either minimal or no involvement in planning. And, at no project was there evidence of anything more than minimal district involvement in actual project operations. For example, at one project, which brought together top district and university administrators (superintendent and vice president of academic affairs at the university) for general planning, the project leaders reported that the school district officials were supportive of the project but were not actively involved. In fact, one of the project leaders complained of a lack of cooperation between the district and the project, stating that school district officials were reluctant to have anyone in the schools collecting data. *"They think it will be evaluative of them and will reflect poorly on them."*

In summary, the GK-12 projects seem to be developing and strengthening positive relationships between faculty and students at the participating universities and teachers and principals in the local school systems. Since these relationships can serve as the bases for future collaboration, this represents a major accomplishment of the program.

IV. Teachers' Increased Content Knowledge as an Impact of Their Participation in the GK-12 Fellowship Program

Many teachers reported a gain in content knowledge due to participation in the GK-12 Fellowship Program. Teachers reported not only gaining content knowledge, but also other important skill sets, such as new teaching strategies. Some teachers indicated a greater understanding and incorporation of technology in their classrooms due to participation in GK-12; others described learning new activities and lesson plans that they could use in the years to come without the presence of the Fellows.

Teachers at all twelve sites visited reported that participation in the GK-12 Fellowship Program had improved their content knowledge. Not every teacher reported content knowledge gains. At a few sites, some teachers who indicated that they had not increased their content knowledge. For example, one teacher reported that because the Fellow's area of expertise was not in the science area he was teaching, he was unable to gain relevant content knowledge from the Fellow. The teacher did report learning a lot about the Fellow and his research.

Teachers, Fellows, and principals provided numerous examples of increased teacher content knowledge. Teachers reported the following:

- One teacher reported that she had become more knowledgeable about topics that she previously taught "superficially."

- Another teacher reported teaching a science class for which he had no background and lacked resources. The Fellow was able to provide both for her.

- Another teacher stated, *"The Fellow would explain things that I often had misconceptions about... I've become more aware of the science in everything."* - One teacher reported that the Fellow helped her prepare for the National Board certification by discussing technological issues.

Fellows confirmed increased teacher content knowledge.

- One Fellow reported that the teacher he worked with now used more manipulatives and has added more problem-solving in the class.

- At another project, after the teacher would ask the Fellow in class *"Can you confirm that,"* the Fellow and teacher would get together after class and discuss the topic.

Seven principals indicated that their teachers were strongly increasing their content knowledge. For example,

- One principal interviewed stated that when he began at the school the mathematics program was dismal. As a result of the GK-12 project, *"teachers who were pessimists became optimists."*

- Another principal noted significant content gain for his faculty, particularly because self-contained classroom teachers were unlikely to have a high level of training in the sciences.

Teachers reported acquiring other skills sets besides increased content knowledge as a result of participation in the program. Teachers in five projects indicated an increased understanding and use of technology due to the technological expertise that Fellows brought to the classroom. In one project the teachers learned programs such as PowerPoint, Excel and Probware, and other technological skills such as web development. One teacher commented that she learned how to use technology and integrate it into her instruction. In another project a teaching aide was initially nervous about teaching a computer lab. As a result of working with the Fellow, she was more confident about teaching computer lab and using the materials the Fellow developed. As a result of her participation in the program, she was able to create similar materials. Two principals also reported an increased computer knowledge and exposure to technology for their teachers. In fact, teaching their teachers technology was an explicit goal reported by at least two Fellows.

Teachers also learned new ways to approach their subjects. One teacher reported that her students' test scores were low in mathematics so she asked the Fellow to find articles identifying successful methods other teachers were using to improve students' skills. In four projects, teachers reported a new attitude and outlook on their subjects. In another project, teachers said Fellows had influenced their teaching styles. A teacher interviewed indicated that the Fellow helped her realize that *"you can't teach math as a process. You have to teach them [the students] what they're doing."* The way she taught math had changed; before she *"used to just teach them lessons, how to do things rather than get them to understand."* This statement was reinforced by other teachers in the same project who stated that they learned that there was more than one way to solve a problem. Based on the activities some Fellows did in the classroom, three teachers

indicated that they learned that they could further challenge their students. One of these teachers commented, *"I now try to teach more science content skills rather than just facts and figures. He [the Fellow] has shown me not to be afraid to challenge them [the students] more with higher-level stuff."*

Principals also echoed these sentiments. Three principals commented that their teachers had learned new teaching strategies. One of these principals appreciated the opportunity for his teachers to reevaluate their teaching techniques and discover new approaches to teaching science.

Teachers were also provided with science and mathematics activities and new ways to teach the content. Teachers from seven projects reported receiving hands on exercises, new activities, and units that the Fellows created; many teachers liked these activities because they could use them long after the program ended. In one project where Fellows created few activities, teachers suggested one way to improve the program would be to receive more activities from the Fellows.

Teachers in five different projects reported they had benefited from using the Fellow as a resource. Two principals also emphasized the value of the Fellow as a resource in the classroom. Teachers used Fellows to learn about relevant web sites, new research, and ideas to teach science concepts. In two projects, the Fellows were seen as a resource between the university and the teachers. Teachers found long-lasting resources provided by the Fellows as a positive aspect of the program. In three projects, teachers found the materials and equipment brought by the Fellow as a great benefit.

Teachers in at least three different projects explicitly reported they had greater enthusiasm for the subject matter due to participation in the program; teachers at four projects reported that science or mathematics is more exciting now after their participation. This was also noted by the internal evaluator of one of these projects and a principal who commented that a scientist in the classroom added a "boost of energy." At another site, elementary teachers indicated they were doing more science due to participation in the program.

Other benefits that teachers reported included the benefit of having an additional person in the classroom. In six projects teachers reported that having the Fellows in the classroom made it easier to "cover many kids." One teacher commented, *"An extra adult in elementary school is a godsend."*

Summary Findings

The following summarizes the final "Summary of Findings" sections of the GK-12 site visit reports. It should be noted that these summary sections were subject to the interpretations of the writers; thus, what is included below are what the researchers considered to be the "strongest areas of the GK-12 project," "areas that may be less strong," and "implications for the GK-12 Program as a whole."

Strongest areas of the GK-12 projects. The four most often cited "strongest areas" of the GK-12 projects were:

1) *Content knowledge gains for teachers* (five sites). Teachers in these projects reported that their content knowledge had increased as a result of working with "experts" in science.

2) *Positive role models for students* (four sites). At one site, the PI explained that the presence of a Fellow provided students with a role model "who is really enthusiastic, who is interesting, and is also a buddy to the kids." At another site, teachers believed that the presence of positive role models in the classrooms would increase the likelihood that the K-12 students would attend college.

3) *Improved school-university relationship* (four sites). At these sites, improved communication between the universities and K-12 school staff was cited as a strongest area. One PI felt that teachers had become more familiar with the university as a resource, and hoped that teachers would try to initiate or become involved with other projects at the university, saying "[GK-12 project] has given us a chance to get [the teachers'] contact information, and given them a chance to get to know us."

4) *Improved communication and instructional skills of Fellows* (four sites). One Dean felt this was an important aspect of GK-12 for Fellows who will become teachers: "You can be the brightest person [but]...You really know something if you can teach it to someone else." At another site, Fellows reported feeling more confident speaking in front of large groups and found it easier to explain their research to lay people.

Additional strongest areas mentioned include:

1) *Stronger relationships and collaboration between education and science departments at the universities* (2 sites). At one site, education graduate students were conducting an evaluation of the GK-12 project as part of a research design and analysis project.

2) *Enriched teaching of science*. This broad category ranged from increased exposure to "real life" science (one Dean said, "Students get [an experience] as close to the real world as possible]"), to a greater exposure to inquiry-based instruction (three sites). At one site, teachers reported that their students were having many new experiences and were experiencing more and better science than they could have without the Fellows. In addition, it was reported that the Fellows brought ideas for new activities (one site), brought new materials and equipment (two sites), and greater enthusiasm for science (three sites).

3) *Strong leadership and management of the project* (three sites). One strongest area cited in four projects was strong leadership by the PI, co-PIs, and project coordinators. The presence of a project coordinator helped to relieve the burden on the PI and co-PIs to handle the day-to-day management of the project.

Additional areas of strength were specific to individual sites. For example, one site had a particularly strong match of Fellows with teachers; one had a strong training program; one defined the roles of the Fellows and teachers particularly well; and one had helped to increase the stipends of students in other support programs.

Areas that may be less strong. The two most often cited "less strong" areas for GK-12 projects were:

1) *Clarification of the Fellows' and teachers' roles*. This was an issue brought up in five of the twelve sites. In one site it was found that the role of the Fellows, if unclear, could result in the Fellows being overwhelmed (if the teachers viewed the Fellows as student-teachers), or in the Fellows being insufficiently used (if the teacher had not been prepared to have a science expert in the classroom). The role of the teacher, if unclear, could result in the teachers feeling burdened (if they had expected the Fellows to help with classroom

management), or intruded upon (if they had not expected an expert in the classroom). At another site, a Fellow complained that one teacher with whom he worked sometimes left the classroom and expected him to take over. For some sites this was an issue when the project first started and was worked out as the year progressed.

2) *Summer training*. In five sites, Fellows and teachers found that the summer training had been inadequate. In some cases this meant that the Fellows did not feel well-prepared for classroom work, and in other cases Fellows and teachers felt they should have had more time during the summer to get to know each other and to plan for the upcoming school year. Several sites were working to improve the summer training.

Additional areas that were cited by more than one site as "less strong" included

1) *The weekly/biweekly seminars*. At three sites, the Fellows found that the seminars could have been made more relevant to the work they did in the classrooms and provided more opportunities to solve problems. One Fellow felt intimidated at the weekly seminar at her site, and therefore did not speak up often.

2) *The matches between Fellows and teachers* (three sites). In some cases, the project leadership had difficulty identifying good matches in terms of content and subject area. At one site, there was concern that Fellows who were matched with teachers unprepared to work with Fellows were not able to have the same influence or success as those paired with open-minded teachers who were excited to try new things.

3) *Formal feedback for the Fellows*. At three sites, Fellows mentioned the need for more formal feedback on their performance and pedagogical skills. At one of these sites, Fellows were not aware of the impact they were having on teachers because they had not received feedback from project leaders.

4) *Planning time between Fellows and teachers during the year*. At three sites, Fellows and/or teachers expressed a need for additional time to work together during the year.

Finally, site-specific areas that were less strong included long commutes to school sites, issues with both teachers' compensation and undergraduate Fellows' compensation, and issues resulting from late notification of the grant by NSF (see "Implications" section below).

Implications for the GK-12 Program as a whole. The most often cited implication for the GK-12 Program as a whole was sustainability. This was raised in seven of the twelve projects. At one site, the PI believed that the Dean's Office could potentially support only two Fellows. At another site the economic downturn following the September 11th terrorist attacks resulted in funding cuts at the University. It was feared that these cuts would potentially eliminate any future support for the GK-12 project. On the same note, one PI said, "... the administration doesn't feel it needs to give so much... [State] always says it has no money. The events of 9/11 made this worse. It is hard to piece lots of different grants together to fund one fellowship." One PI thought that some aspects of the GK-12 project could be incorporated into other outreach projects already in place, but at another site the PI just did not believe that sustaining the project was possible. One site experienced a unique circumstance in terms of sustainability – the PI felt that the pool of graduate students was too small to recruit Fellows in future years.

Another implication for the GK-12 Program as a whole was the hiring of a project coordinator. This was cited in four of the twelve projects as an action that would be worthwhile

for other sites to purse. At these sites, having a project coordinator who handled the day-to-day management of the project reduced the burden on the PIs and provided a point person for questions and concerns that arose with Fellows and teachers.

Finally, several sites had unique processes or characteristics that may be useful for other projects (or universities that are applying for GK-12 grants) to utilize. For example, several sites built their GK-12 projects on existing outreach programs, formed partnerships between education and science departments at the universities, or developed a teacher driven model that worked well. Some sites experienced problems that may be encountered by other projects, including long commutes to schools, the need for communication between Fellows and teachers during the summer, issues of local school control, or difficulty creating good matches between Fellows and teachers.

Conclusions/summary. The GK-12 Program appears to be meeting its goals. In order to better determine the extent to which the program has been successful -- that is, the degree to which these findings characterize the universe of GK-12 projects, surveys of all of the PIs, all of the Fellows, about 1,000 cooperating teachers, about 1,000 graduate students not receiving GK-12 support (to serve as a comparison group), and school district staff in participating school districts are being conducted. In addition, another twelve case study site visits (using the same methodology and instruments) are being conducted. These data will allow stronger conclusions to be drawn about whether and to what extent program goals are being met.

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